Functionally Tailored Multi-Component Composite Structures via Additive Manufacturing

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Abstract:
This proposal is a follow-on activity to the successful 2012 Phase I ARMD Seedling project, entitled "Functionally Tailored Multi-component Composite Structures via Additive Manufacturing", that was completed last year. The primary objective of the Phase I project was to design a structure with a built-in residual stress field that could alter the mechancial performance of the overall structure. To accomplish this, a bi-metallic composite structure was made where one of the metallic components was a shape memory alloy (SMA) material. Through careful processing, this SMA component of the structure can introduce a controlled internal residual stress field to the overall part. This stress field, if properly designed, can affect crack nucleation and growth behavior. In essence, the technology in this proposal creates a structure with improved durability and damage tolerance. This concept could have wide application in aero structural systems.

In the Phase I effort, a demonstration article was made that validated the concept. Additive manufacturing (AM) was used to fabricate open cell lattice structures in a conventional titanium alloy. These structures were subsequently filled with nickel-titanium shape memory alloy powder and consolidated into a fully dense structure. These structures were then processed in order to create a residual stress field in the part and the stress fields were validated through destructive testing methods. The Phase I project proved the validity of the concept and the detailed results are given in Section 8.0. This Phase II effort will take the next step forward and evaluate the fatigue behavior of these composite materials and determine exactly how cracks initiate and grow in the presence of built-in internal stress field.